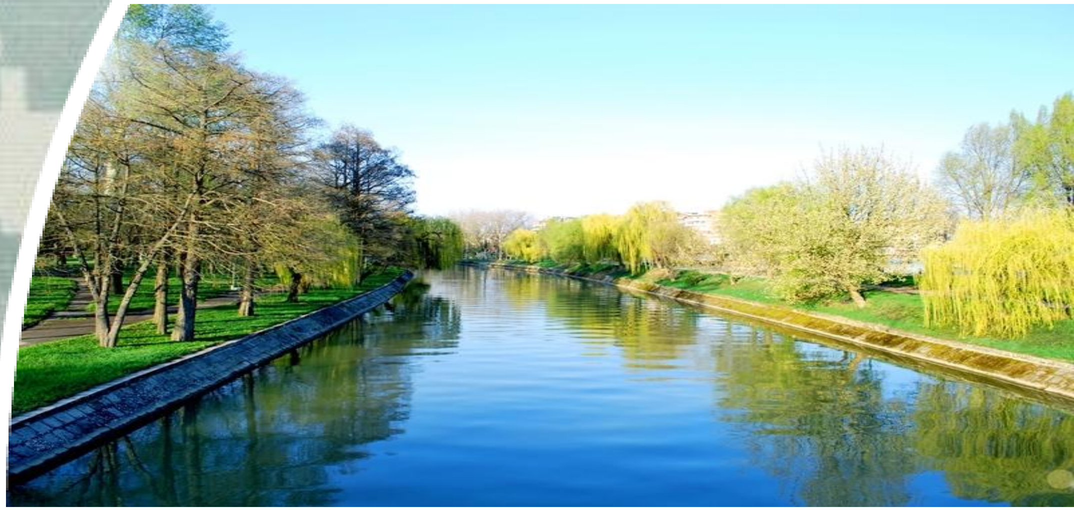
Low Impact Development in Army Construction

Rumanda Young,
U.S. Army Corps of Engineers
Fort Worth District

Patrick Deliman,
U.S. Army Corps of Engineers
Engineer Research and Development Center
Vicksburg, Mississippi



US Army Corps of Engineers
BUILDING STRONG®

Report Documentation Page

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LID Definition

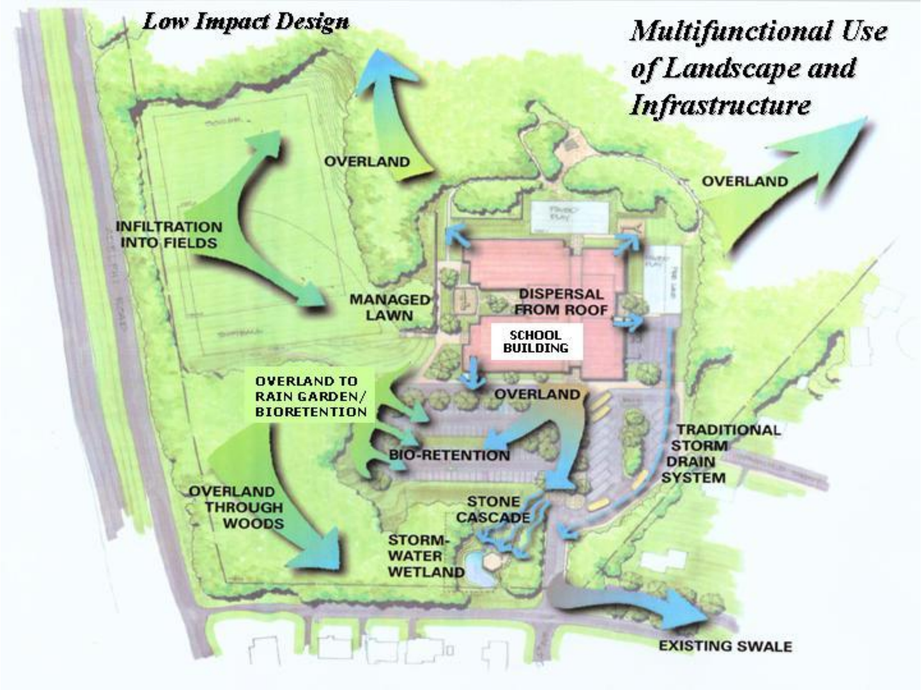
LID is a stormwater management approach with basic principles modeled after nature.

The primary goal of LID is to mimic a site’s pre-development hydrology by managing runoff close to its source through:

- infiltration
- filtration
- storage
- evaporation
- detention

LID Philosophy

Hydrology is an organizing principle that is integrated into the initial site assessment and planning phases.

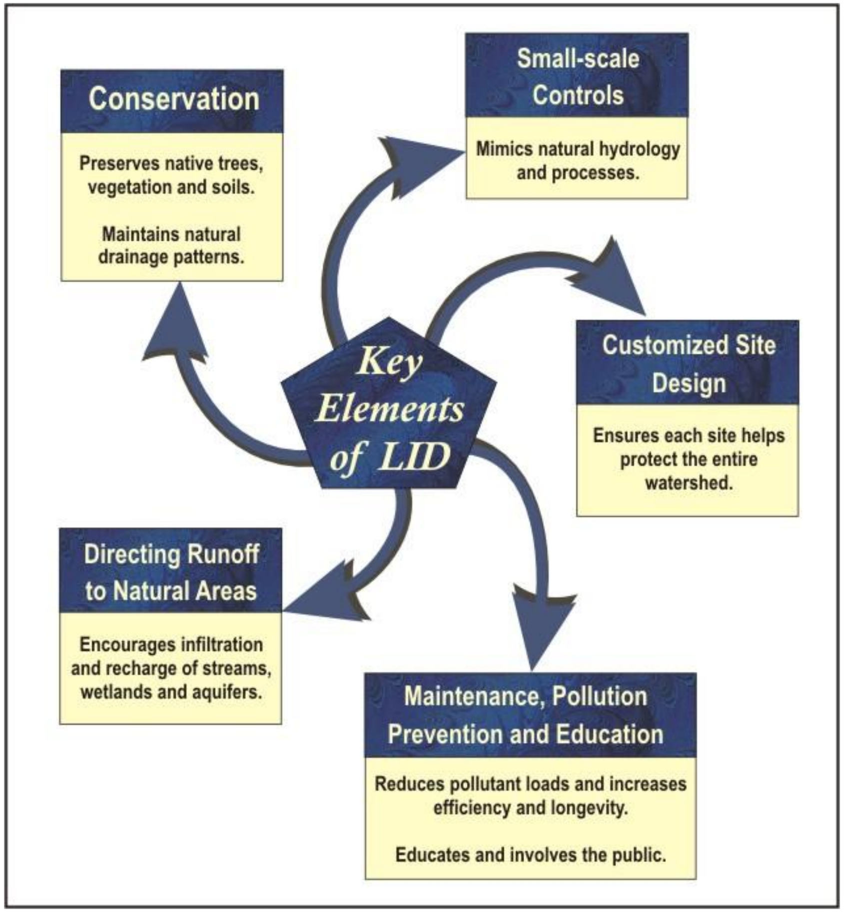


Source: Low Impact Development Center

LID Philosophy

The goal of LID site planning is to allow for full development and function of the intended site activity while maintaining the site's essential natural or existing hydrologic function.

LID techniques are used to modify hydrologic processes, such as infiltration or storage, to meet the specific water quality, water quantity, and natural resource objectives



LID – Green Infrastructure

- The green infrastructure movement began in the 1990's, when Florida, Maryland, and other states initiated programs to strategically identify, and protect connected open space systems.

- In 1999, the President's Council on Sustainable Development identified green infrastructure as one crucial element that provides a comprehensive approach for sustainable community development.

- Green infrastructure provides several benefits, including:
  - Enriched habitat and biodiversity
  - Maintenance of natural landscape processes
  - Cleaner air and water
  - Increased recreational and transportation opportunities
  - Improved health
  - Connection to nature and sense of place

Conventional Conveyance

There are several issues related conventional storm water conveyance systems, including:

- Site changes/re-grading
- Loss of recharge
- Increased water temperature
- Decreased water quality
- Higher run-off volumes
- Expensive costs
- Infrastructure repair

An important low impact development principle is the idea that storm water is not merely a waste product to be disposed of, but rather that rainwater is a resource.

LID Limitations

- Site conditions may limit the appropriateness of LID practices. Evaluation of soil permeability, slope and water table depth must be considered in order to effectively use LID practices.

- Regulation limitations may necessitate the use of structural BMPs in conjunction with LID techniques in order to achieve watershed objectives.

- Perception of the potential of flooding without conventional storm sewers may limit LID implementation.

LID Policy

- Title 42, USC, Chapter 52, Section 17094, Section 438 Energy Independence and Security Act, December 2007.
- Executive Order 13423 of January 24, 2007
- Executive Order 13514 of October 5, 2009
- 33 U.S.C. 1251 Clean Water Act

EISA Section 438

- Energy Independence and Security Act

"Storm water runoff requirements for federal development projects. The sponsor of any development or redevelopment project involving a Federal facility with a footprint that ***exceeds 5,000 square feet*** *shall use site planning, design, construction, and maintenance strategies for the property to* ***maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow.****"*

Executive Order 13423

- E.O. 13423 requires Federal agencies to ensure new construction and major renovations comply with the **2006 Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding (MOU)**. It also requires that 15% of the existing Federal capital asset building inventory of each agency incorporate the sustainable practices in the Guiding Principles by the end of fiscal year 2015.

  Outdoor Water. Use water efficient landscape and irrigation strategies, including water reuse and recycling, to reduce outdoor potable water consumption by a minimum of 50 percent over that consumed by conventional means (plant species and plant densities). Employ design and construction strategies that reduce storm water runoff and polluted site water runoff.

Executive Order 13514

- E.O. 13514 expands the water efficiency requirements of E.O. 13423 and the Energy Independence and Security Act (EISA) of 2007. E.O. 13514 does not supersede either regulation, but does require Federal agencies to improve water efficiency and management by:

  Reducing potable water consumption intensity 2% annually through FY 2020, or 26% by the end of FY 2020, relative to a FY 2007 baseline.

  Reducing agency industrial, landscaping, and agricultural volumetric water consumption 2% annually, or 20% by the end of FY 2020, relative to a FY 2010 baseline.

  Identifying, promoting, and implementing water reuse strategies consistent with state law that reduce potable water consumption.

Clean Water Act

- Restoration and maintenance of chemical, physical and biological integrity of Nation’s waters.

Nonstructural BMPs

What does nonstructural mean?

The primary LID characteristic of nonstructural BMPs is preventing stormwater runoff from the site. This differs from the goal of structural BMPs which is to help mitigate stormwater-related impacts after they have occurred.

More specifically, nonstructural BMPs take broader planning and design approaches, which are less "structural" in their form. Many nonstructural BMPs apply to an entire site and often to an entire community, such as wetland protection through a community wetland ordinance. They are not fixed or specific to one location. Structural BMPs, on the other hand, are decidedly more location specific and explicit in their physical form.

Conceptual plan using conservation design principles
Source: EPA

Nonstructural BMPS

The nonstructural BMPs are:

- Cluster development
- Minimize soil compaction
- Minimize total disturbed area
- Protect natural flow pathways
- Protect riparian buffers
- Protect sensitive areas
- Reduce impervious surfaces
- Stormwater disconnection.

Left and right source: Growing Greener: Putting Conservation into Local Codes. Natural Lands Trust, Inc. 1997

Structural BMPs

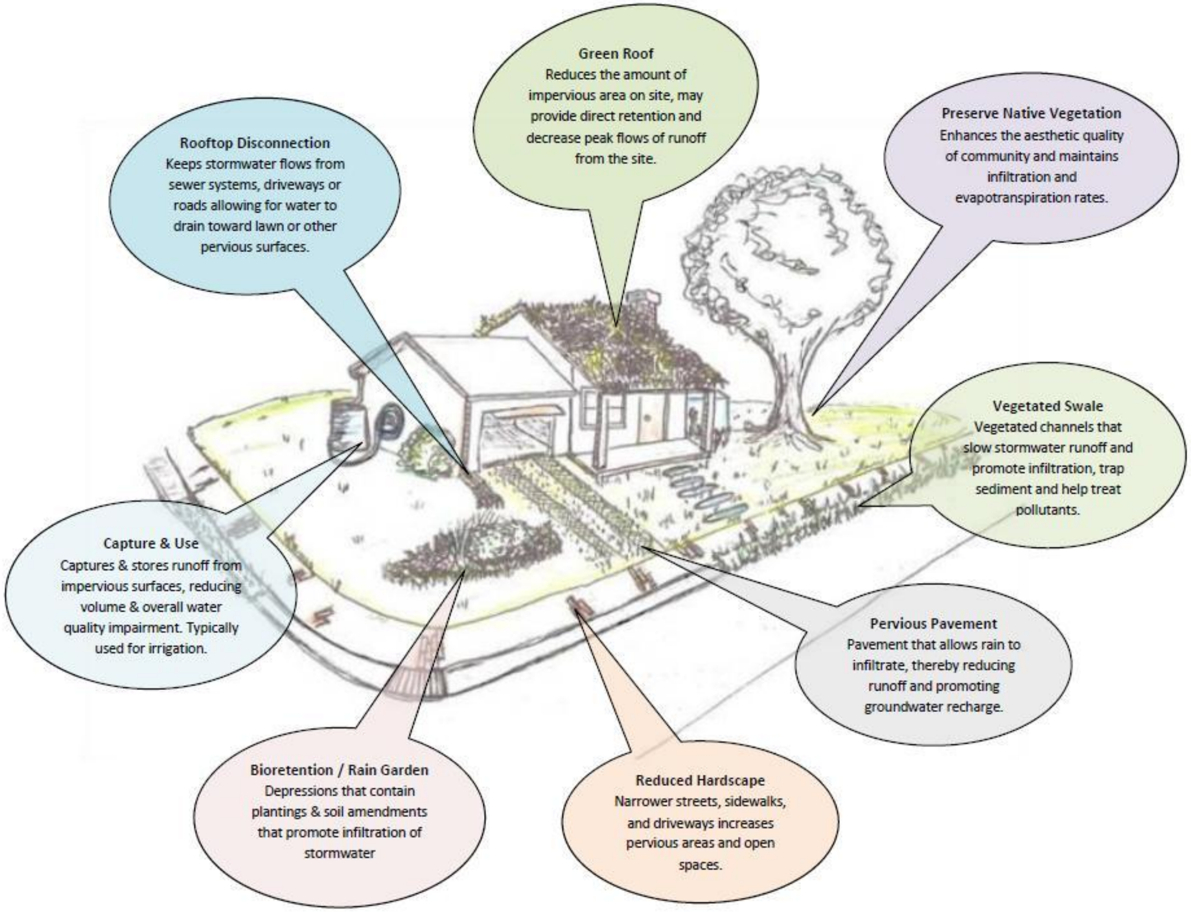
- Bioretention (rain gardens)
- Capture reuse
- Constructed filter
- Detention basin
    - Dry pond
    - Wet pond
    - Underground system
    - Constructed wetlands
    - Bioretention
- Infiltration practices
    - Dry well
    - Infiltration basin
    - Infiltration berm
- Infiltration trenches
- Subsurface infiltration beds
- Bioretention
- Level spreaders
- Native revegetation
- Pervious pavement with infiltration
- Planter boxes
- Riparian buffer restoration
- Soil restoration
- Vegetated filter strip
- Vegetated roof
- Vegetated swale
- Water quality devices

Structural BMP Selection

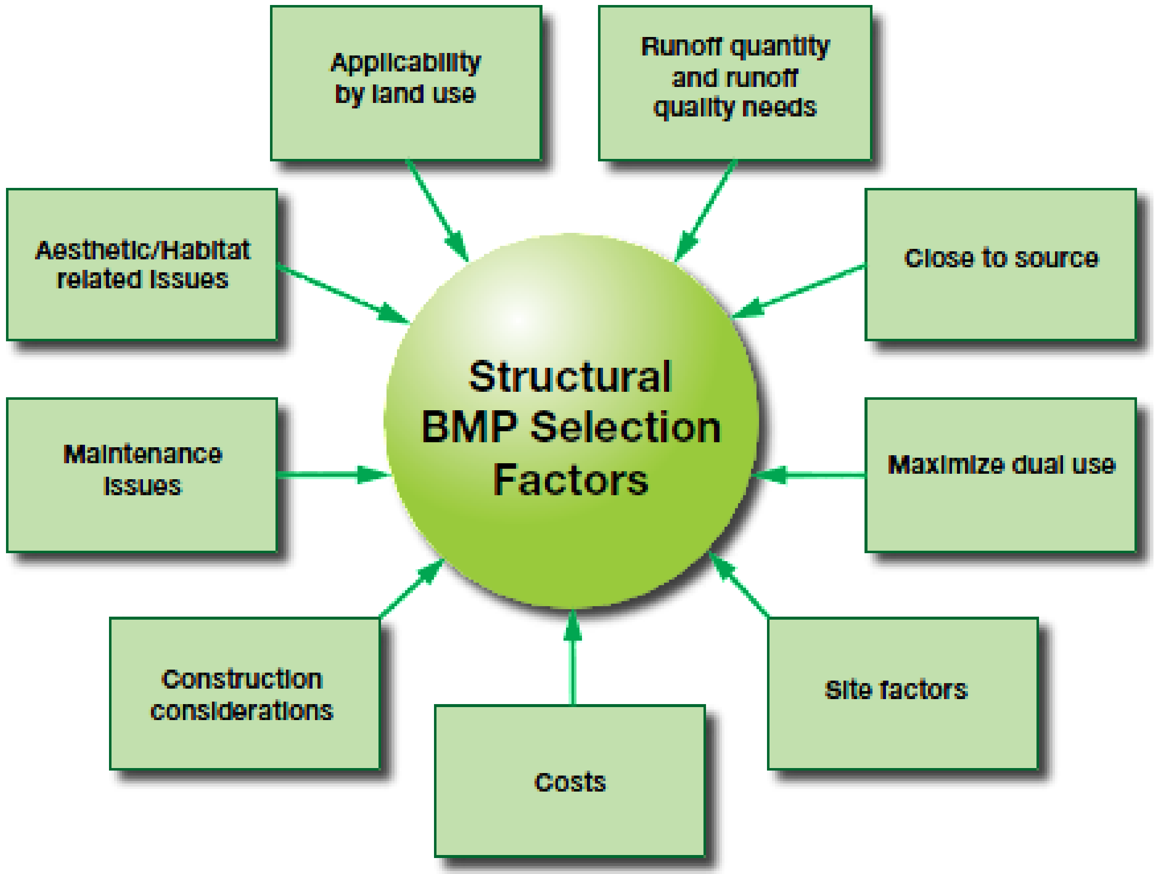
Development Planning:

- First Goal: prevent as much stormwater runoff as possible on a site through nonstructural planning.

- Second Goal**:** mitigate stormwater runoff as efficiently as possible through structural planning and design.



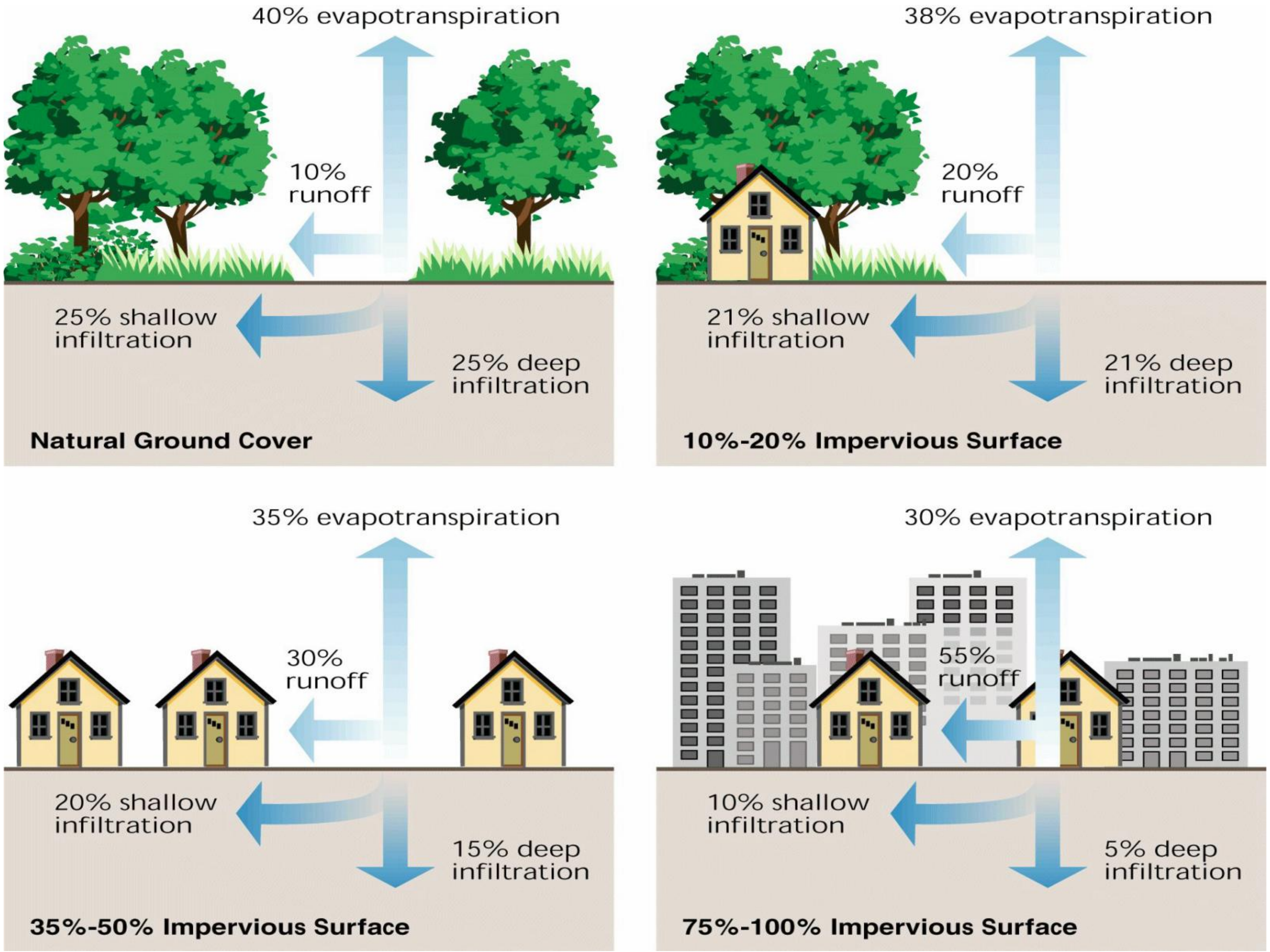
Structural BMP Selection Factors



LID Program Development

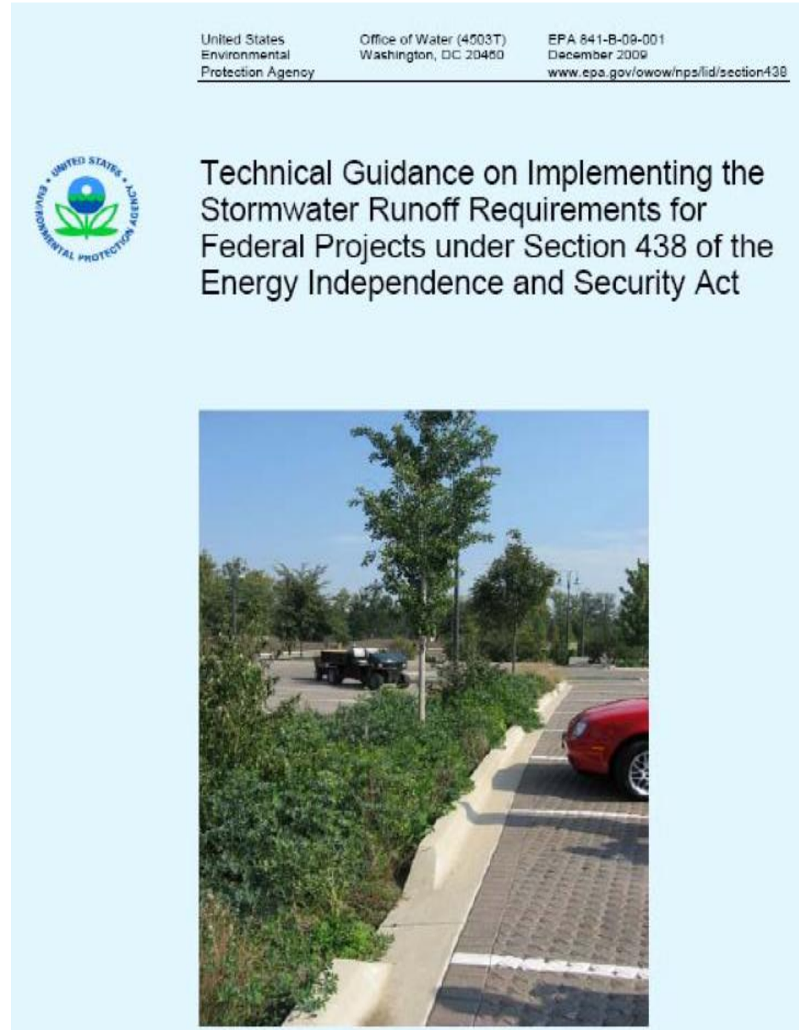
- **OACSIM has requested USACE to provide Low Impact Development (LID) program development support. USACE will lead a Team of experts to develop the Army's LID program by completing the following:**
  - **LID Technical User Guide**
  - **LID Engineering Design Standards and Construction Specifications**
  - **LID Training Workshops (Beginning June 2011 in Austin, TX)**
  - **LID Standard Operating Procedure**
  - **LID Performance Plan**

Pre and Post-Development Hydrology (USDA)



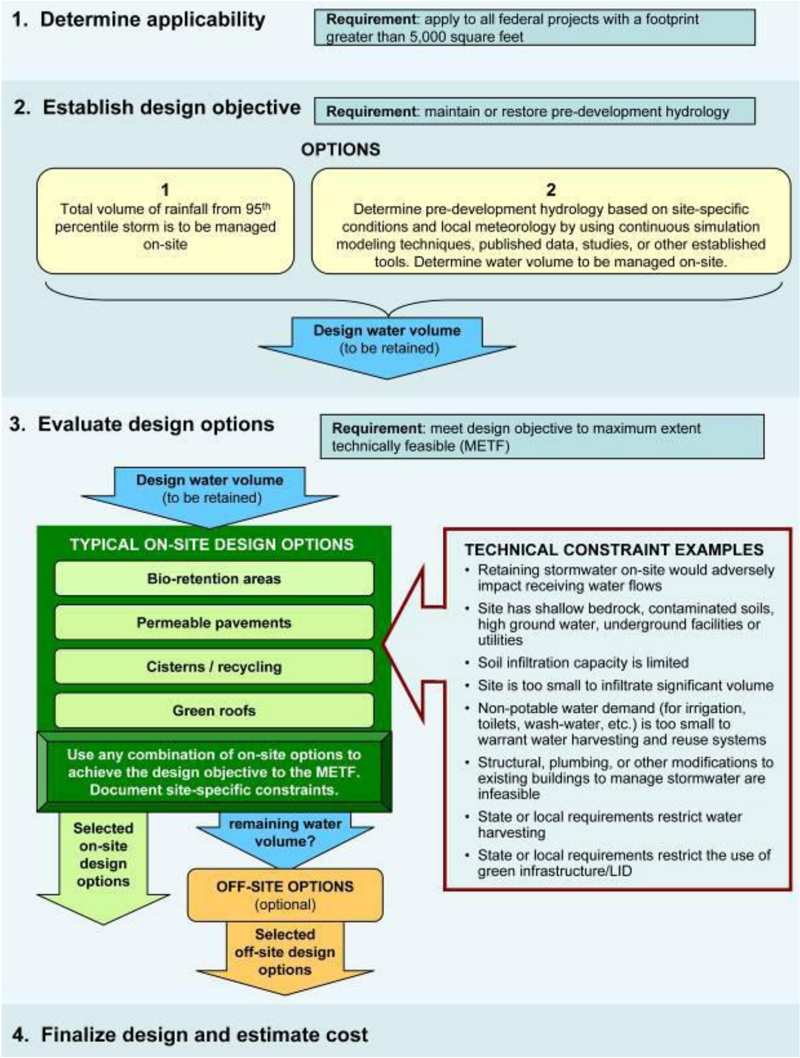
EPA Technical Guidance

EPA 841-B-09-001
December 2009
www.epa.gov/owow/nps/lid/section438


United States Environmental Protection Agency | Office of Water (4503T) Washington, DC 20460 | EPA 841-B-09-001 December 2009 www.epa.gov/owow/nps/lid/section438

Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act

Staying on Track
With the EPA & DOD Flowchart



Policy Memorandum, Office of the Under Secretary of Defense, January 2010

EPA Technical Guidance on Implementing EISA, 841-B-09-001 December 2009

EISA Compliance Methodology

Maintain or Restore the Pre-development Hydrology

- Select Design Objective Option 1, Manage runoff from the 95th percentile storm event
  - Determine the 95th percentile rainfall event
  - Evaluate Site Conditions including: project boundary, existing vegetation, and soil types
  - Calculate pre and post development runoff volumes (Apply Natural Resources Conservation Service (NRCS) Technical Report 55 (TR55) – Soil Conservation Service Curve Number Method (SCS CN))
  - Manage difference between pre- and post-development runoff volumes
- Evaluate options for Low Impact Development (LID) technique designs to manage increased runoff volume.
  - Consider LID features suitable for project site (LID constraints)
  - Ensure selected LID design manages increased runoff volume for 24 hour period
- Accountability
  - Document calculations for hydrologic design (including LID employed on site)
  - Waiver, if applicable
- Complete a post construction analysis of LID features

Developing the 95th Percentile Storm

Rainfall (in)
0.10
0.10
0.10
0.10
0.10
0.10
0.10
0.10
0.10
0.10
0.10
0.10
0.10
0.10
0.10
0.11
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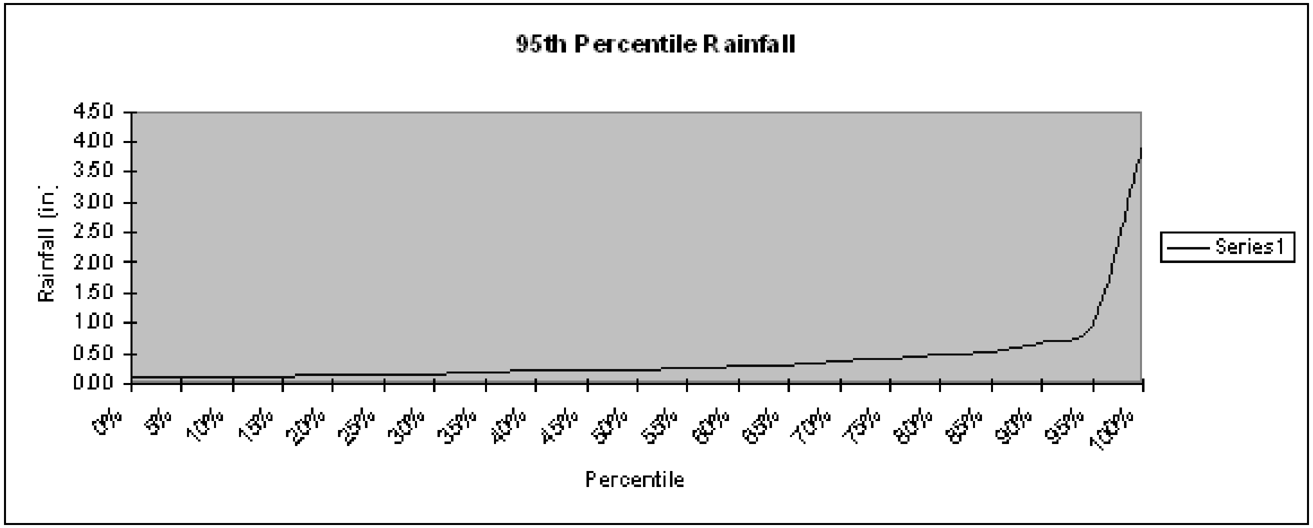
0.11
0.11
0.11
0.11
0.11
0.11
0.11
0.12
0.12
0.12
0.12
0.12

Percentile	Rainfall (in)
0%	0.10
5%	0.10
10%	0.11
15%	0.12
20%	0.14
25%	0.15
30%	0.16
35%	0.19
40%	0.21
45%	0.22
50%	0.24
55%	0.26
60%	0.29
65%	0.31
70%	0.37
75%	0.42
80%	0.48
85%	0.53
90%	0.69
95%	0.98
100%	3.98

95th Percentile Rain
P= 0.9835

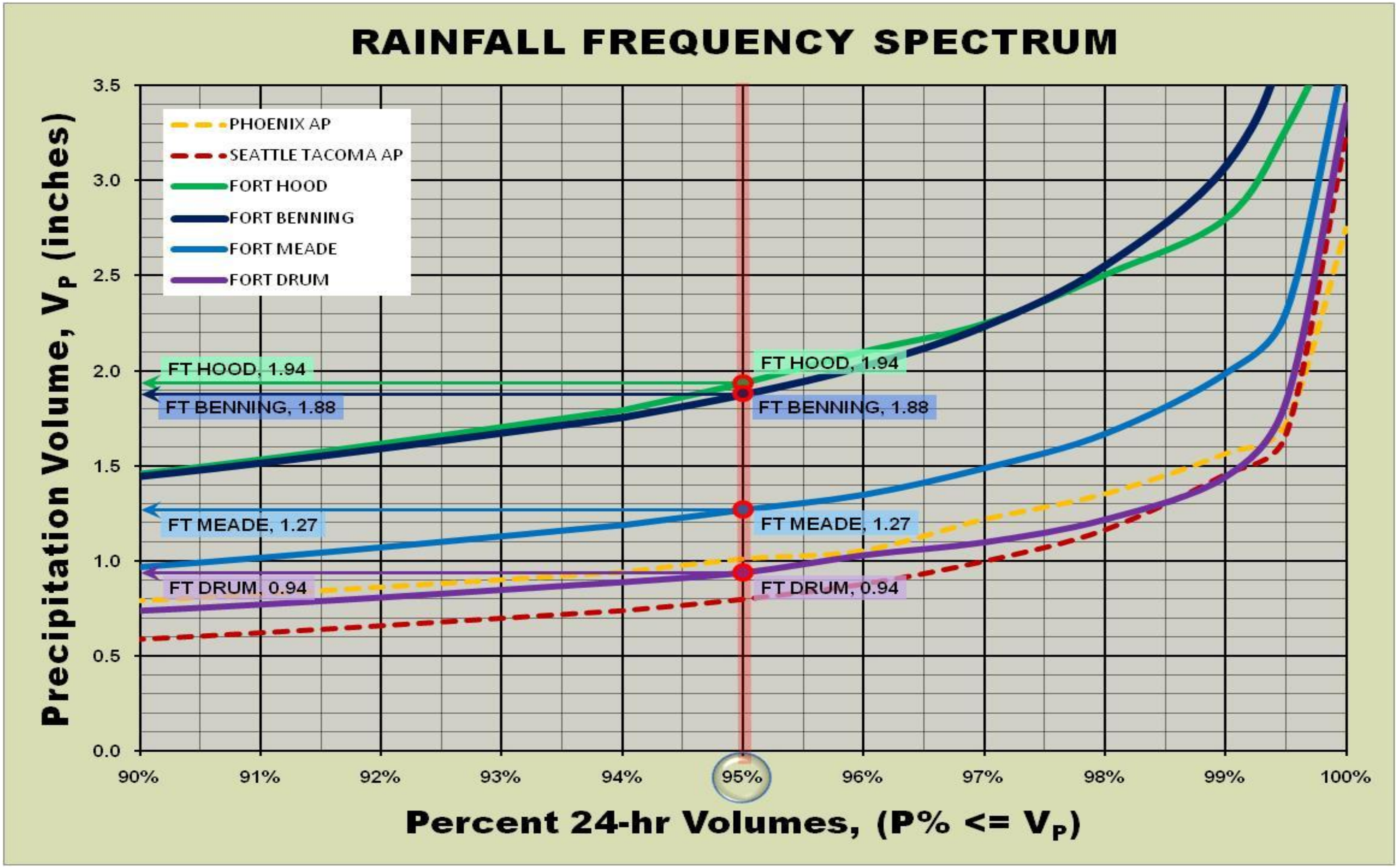


1. Obtain 24-hr precipitation data set (NCDC)
   - http://www.ncdc.noaa.gov/oa/ncdc.html
2. Import into spreadsheet and aggregate into a single column
   - Eliminate storms with rainfall less than 0.1”
3. Calculate using PERCENTILE function or graphically

Example 95^{th} Percentile Storms

City	95^{th} Percentile Event Rainfall Total (in)	City	95^{th} Percentile Event Rainfall Total (in)
Atlanta, GA	1.8	Kansas City, MO	1.7
Baltimore, MD	1.6	Knoxville, TN	1.5
Boston, MA	1.5	Louisville, KY	1.5
Buffalo, NY	1.1	Minneapolis, MN	1.4
Burlington, VT	1.1	New York, NY	1.7
Charleston, WV	1.2	Salt Lake City, UT	0.8
Coeur D'Alene, ID	0.7	Phoenix, AZ	1.0
Cincinnati, OH	1.5	Portland, OR	1.0
Columbus, OH	1.3	Seattle, WA	1.6
Concord, NH	1.3	Washington, DC	1.7
Denver, CO	1.1		

Rainfall Frequency Distribution



Climatology Analysis

	FORT HOOD	FORT BENNING	FORT MEADE	FORT DRUM	PHOENIX AP	SEATTLE TACOMA AP
Start Date	January 1, 1950	January 1, 1959	January 1, 1950	January 1, 1950	January 1, 1950	January 1, 1950
End Date	October 30, 2009	December 31, 2008	October 30, 2009	October 30, 2009	June 30, 2010	June 30, 2010
Years of Data	59.83	50.00	59.83	59.83	58.50	18.75
Total Rainfall	1541.61	2416.94	2428.85	2134.78	432.33	711.97
Average Annual Rainfall	**25.77**	**48.34**	**40.59**	**35.68**	**7.39**	**37.97**
95 Percentile Rainfall Depth	**1.94**	**1.88**	**1.27**	**0.94**	**1.01**	**0.80**
Total Rainfall >= 0.1	1505.38	2352.21	2404.30	1948.43	394.69	668.82
Total Runoff Days	2421	3646	5198	5454	1041	1756
No Runoff Days	15842	14617	16655	12809	1958	1243
Maximum Rain	3.92	5.74	3.72	3.40	2.75	3.25

Evaluation of Site Conditions

- Determine the pre and post development project site conditions
  - Evaluate existing soils (analysis) and surface features across project site
  - Determine the area (sq-ft / acres) of existing and planned: building foot print, parking, sidewalks, etc.
  - Determine the area (sq-ft / acres) of existing vegetation features and the planned changes to the landscape
  - Localized small watershed (adjoining areas for LID project consideration)

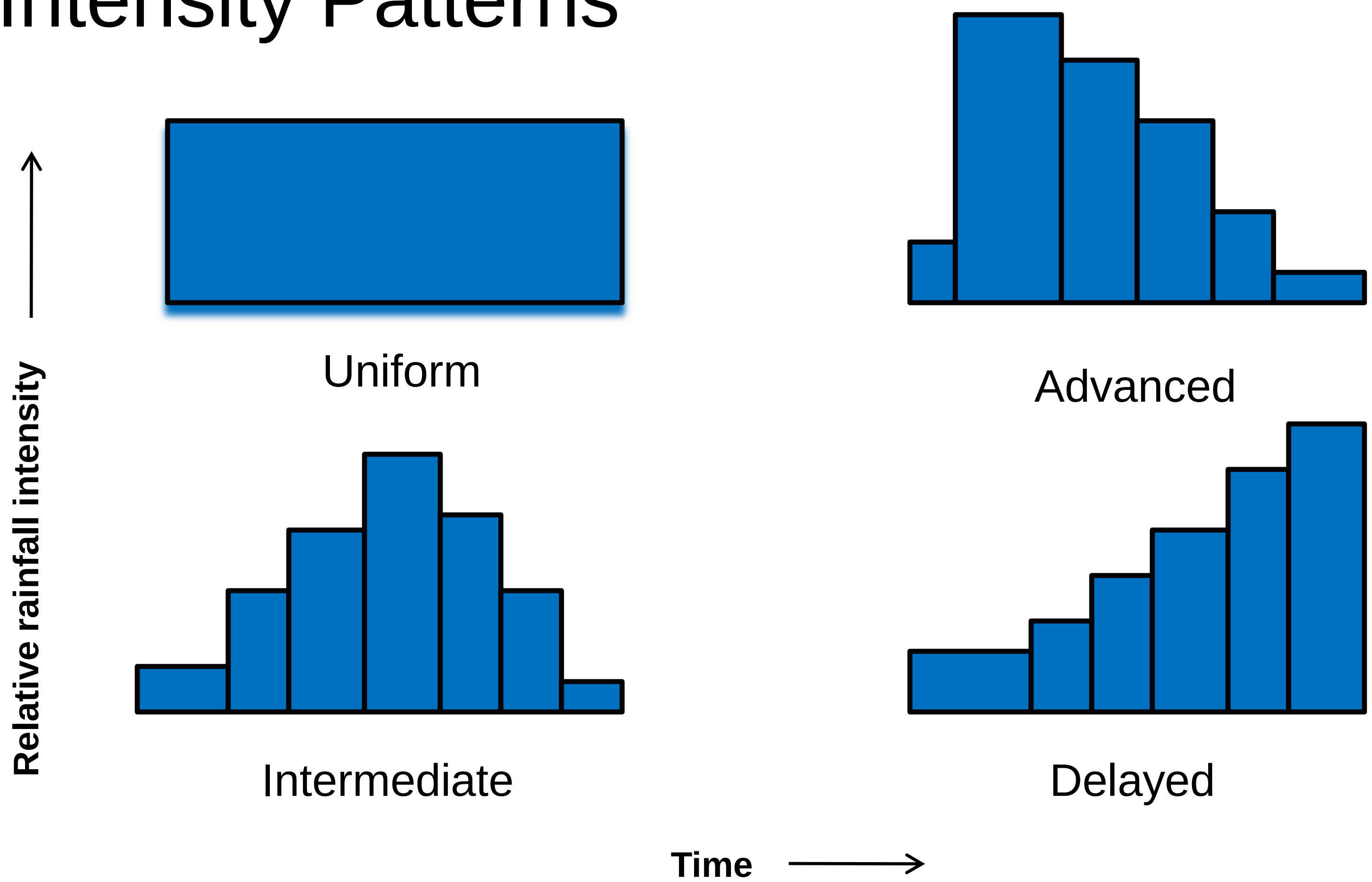
Note: DoD definition of pre-development is pre-project

Hydrologic Cycle Components

- Precipitation
  - Intensity
  - Duration
  - Frequency
- Infiltration
- Evaporation
- Transpiration
- Runoff

Precipitation

- Intensity Patterns



Precipitation Analysis

- Rain Gage
- Hydrologic Frequency
- Average Depth over Area
- Thiessen Method
- Isohyetal Method

Infiltration

- Darcy's Law
- Richards Equation
- Horton

$$f = f_c + (f_0 - f_c)\, e^{-kt}$$

f = *infiltration capacity*

f_c = *constant infiltration capacity*

f_0 = *infiltration capacity at onset*

k = *positive constant for soil*

t = *time*

Infiltration

- US Soil Conservation Service
  - Hydrologic Soil Groups

Hydrologic Soil Group	Soil Type	Characteristic
A	sand, loamy sand, sand loam	low runoff potential, high infiltration rates
B	silt loam, loam	moderate infiltration rates
C	sandy clay loam	low infiltration rates
D	clay loam, silty clay loam, silty clay, clay	high runoff potential, low infiltration rates

Evaporation & Transpiration

- Evaporation from Water Surfaces
  - Dalton's Law

- Evaporation and Transpiration
  - Evapotranspiration
    - Blaney-Criddle
    - Penman
    - Empirical Solar Radiation Method

Runoff

- Rational Method

$$Q = CiA$$

Where Q = Peak Runoff Rate

C = Runoff Coefficient

i = rainfall intensity

A = watershed area

Runoff

- Rational Method Assumptions
  - Rainfall occurs at uniform intensity for duration at least equal to the time of concentration for the watershed.
  - Rainfall occurs at a uniform intensity over the entire area of the watershed.

Runoff Equation

- Soil Conservation Service Method

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

Where: Q = direct flow volume expressed as depth

P = total rainfall

$$S = \frac{1,000}{CN} - 10 \ (when\ water\ depths\ are\ expressed\ in\ inches)$$

$$S = \frac{25,400}{CN} - 254 \ (when\ water\ depth\ expressed\ in\ mm)$$

SCS Runoff Curve Number

Cover Description		Curve Numbers for Hydrologic Soil Group:			
Cover Type and Hydrologic Condition	Average Percent Impervious Area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover less than 50%)		68	79	86	89
Fair condition (grass cover 50 to 75%)		49	69	79	84
Good condition (grass cover greater than 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curves and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-in. sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
$\frac{1}{8}$ ac. or less (town houses)	65	77	85	90	92
$\frac{1}{4}$ ac.	38	61	75	83	87
$\frac{1}{3}$ ac.	30	57	72	81	86
$\frac{1}{2}$ ac.	25	54	70	80	85
1 ac.	20	51	68	79	84
2 ac.	12	46	65	77	82

SCS Runoff Curve Number

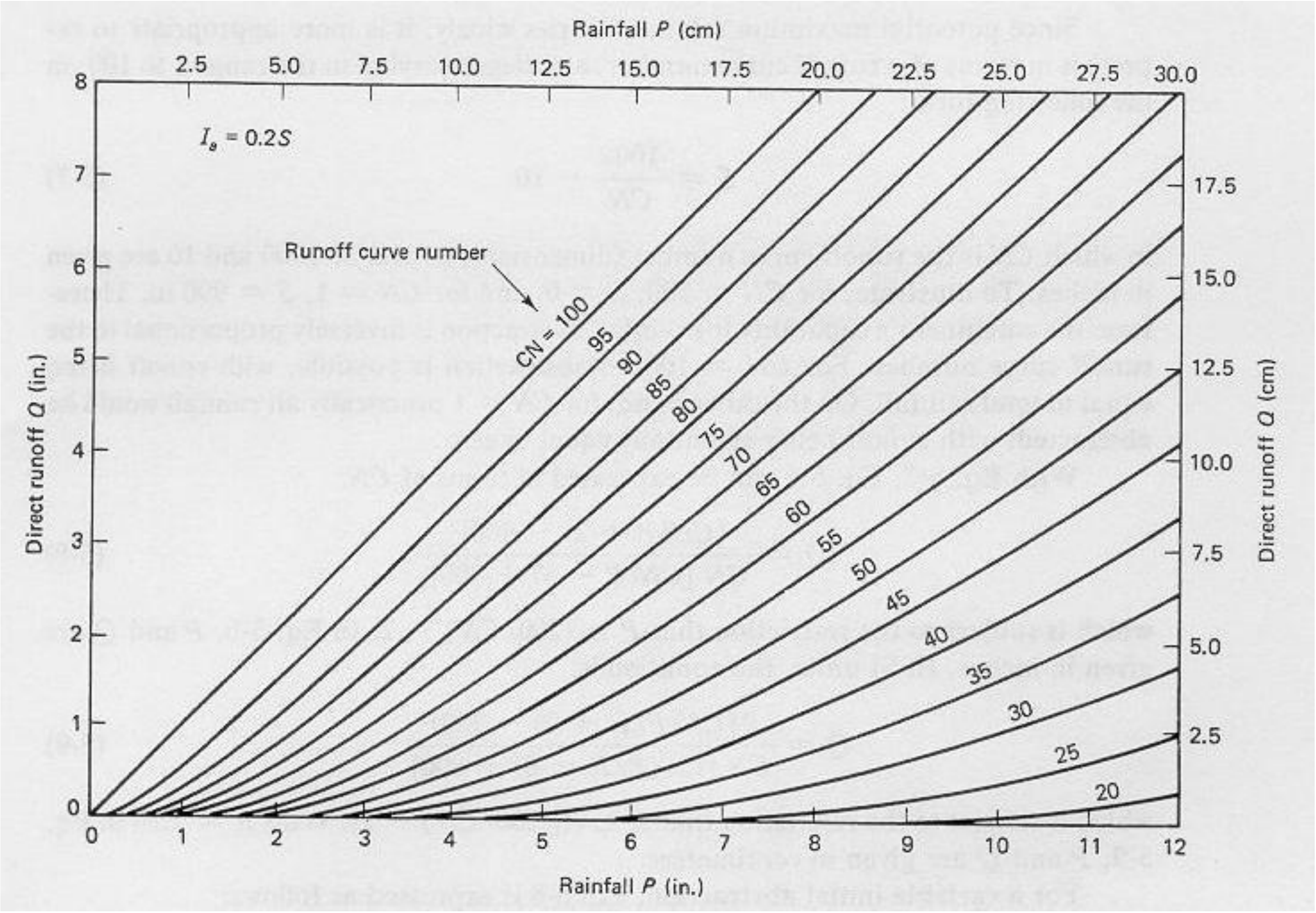
Cover Description		Curve Numbers for Hydrologic Soil Group:			
Cover Type	Hydrologic Condition	A	B	C	D
Pasture, grassland, or range-continuous forage for grazing[2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow-continuous grass, protected from grazing and generally mowed for hay	—	30	58	71	78
Brush—brush-weed grass mixture with brush being the major element[3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30[4]	48	65	73
Woods—grass combination (orchard or tree farm)[5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods.[6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30[4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

SCS Runoff Curve Number

For Planning Purposes

	HYDROLOGIC SOIL GROUP			
LAND COVER	A	B	C	D
WOODED	36	60	73	79
MEADOW	39	58	71	78
BRUSH - WEEDS	35	56	70	77
LAWN	49	69	79	84
ROADS & DRIVES (WO/C&G)	83	89	92	93
ROADS & DRIVES (W/C&G)	98	98	98	98
PARKING & SIDEWALKS	98	98	98	98
BUILDING ROOF	98	98	98	98
BIO-RETAIN AREA	35	55	70	77
VEGETATIVE ROOF	67	67	67	67
PERMEABLE PAVING	50	65	78	85

Solution of Runoff Calculation

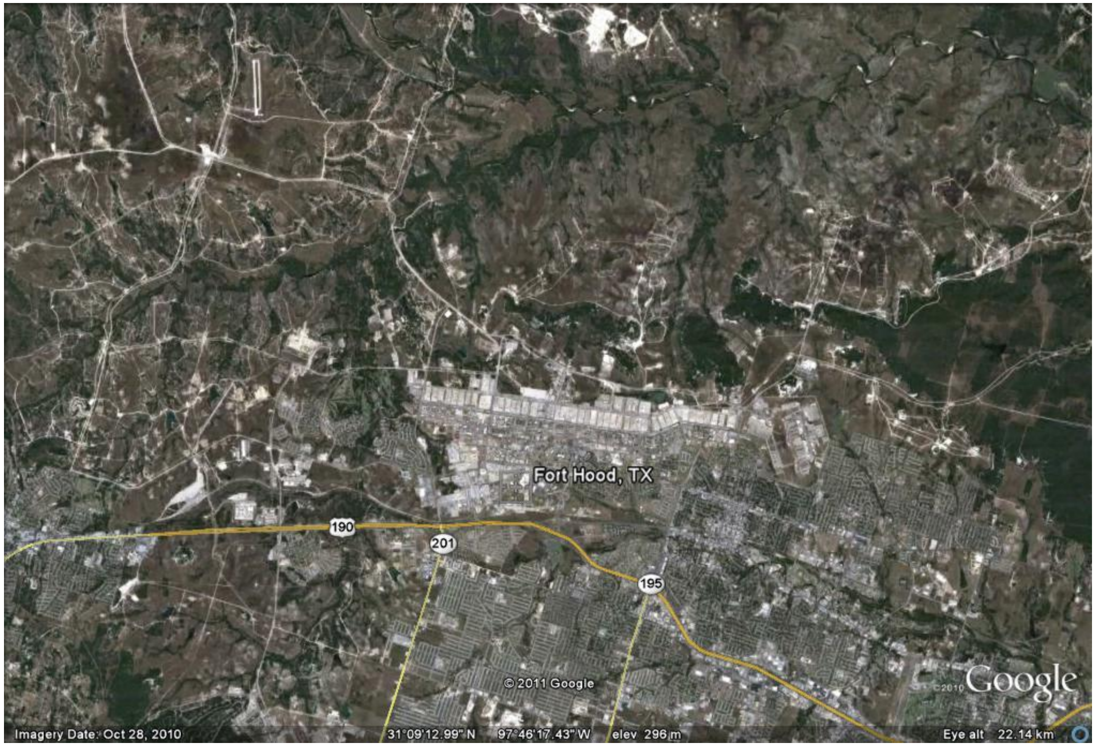


Low Impact Development Strategies

- Bioretention
- Soil Amendments
- Filter Strips
- Vegetated Buffers
- Grassed Swales
- Dry Wells
- Infiltration Basins/Trenches
- Inlet Pollution Removal Devices
- Rainwater Harvesting (Rain Barrels and Cisterns)
- Tree Box Filters
- Vegetated Roofs
- Permeable Pavers

LID Demonstrations

Fort Hood, Texas



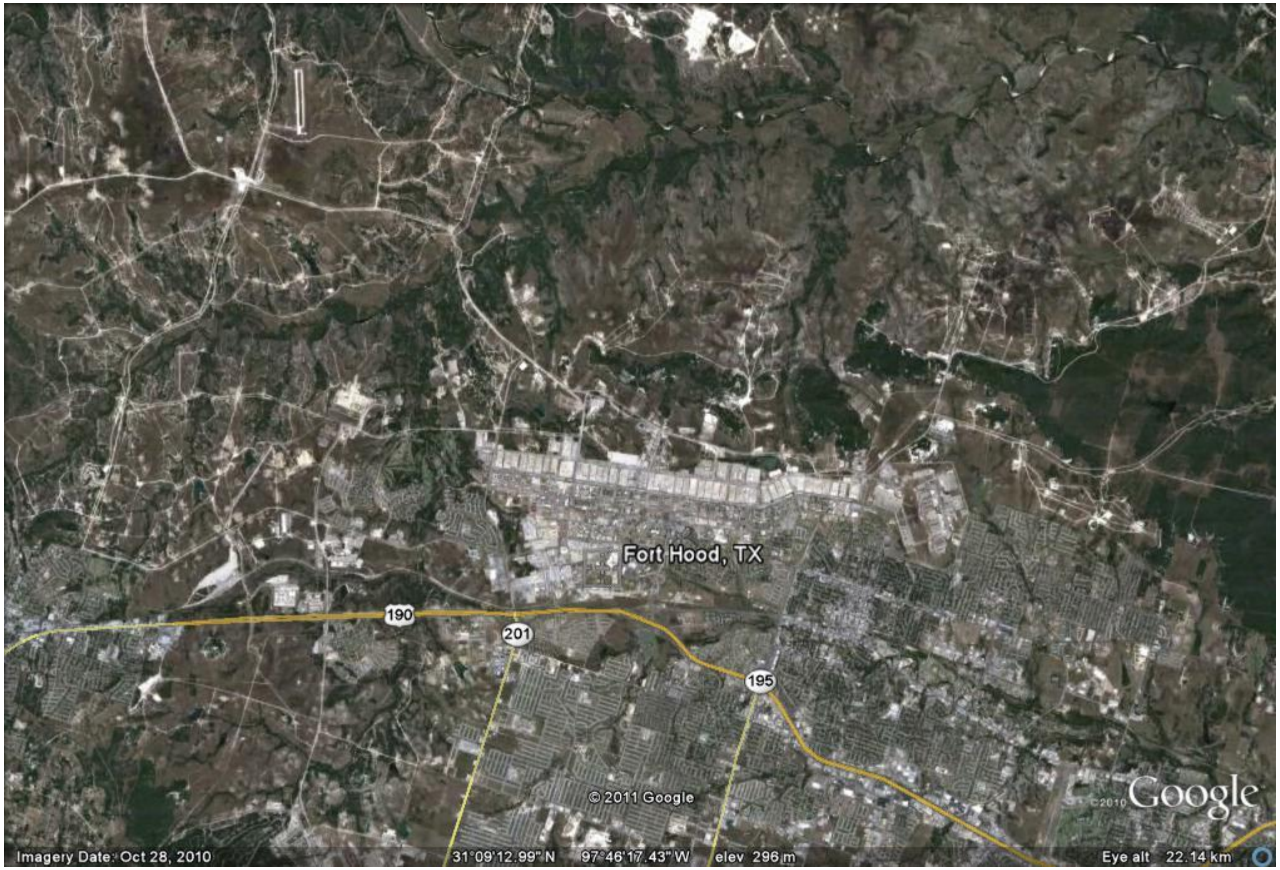
Fort Hood, Texas

Fort Hood is a United States military post located outside of Killeen, Texas,

Fort Hood gets 32 inches of rain per year. The number of days with any measurable precipitation is 64.

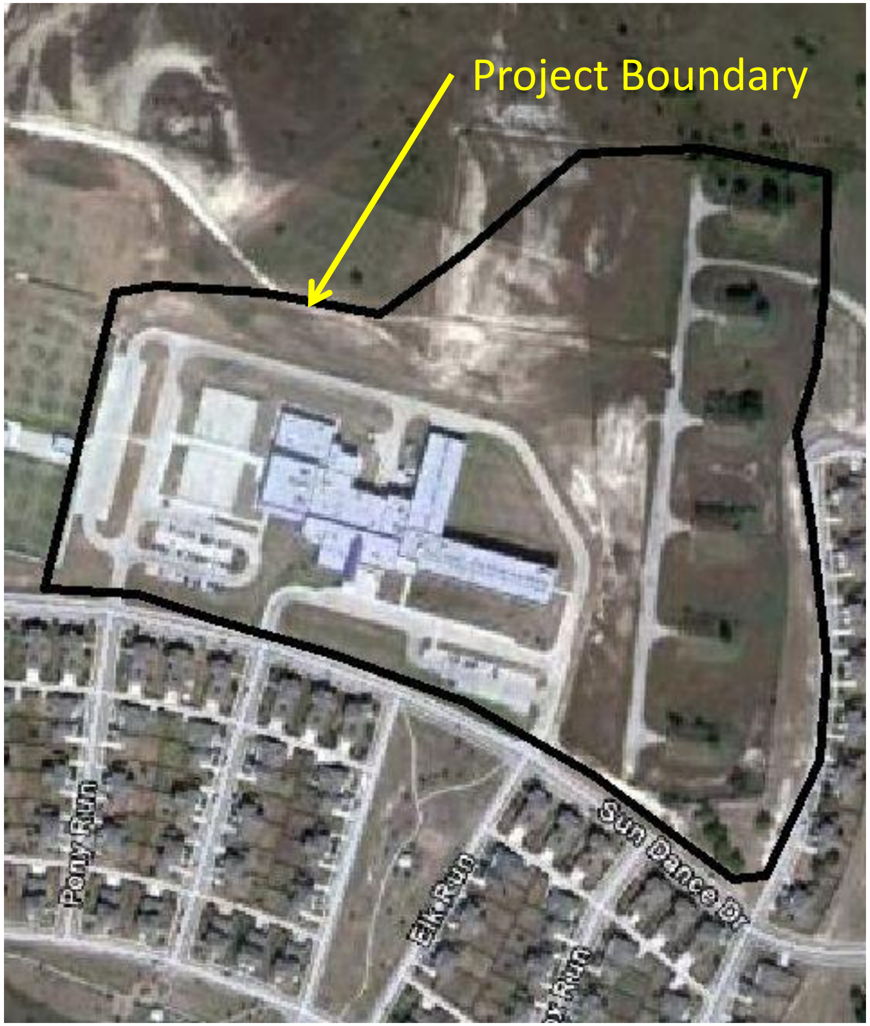
On average, there are 226 sunny days per year in Fort Hood.

The July high is around 96 degrees. The January low is 34.



Fort Hood

New Building Example



Fort Hood

New Building Example

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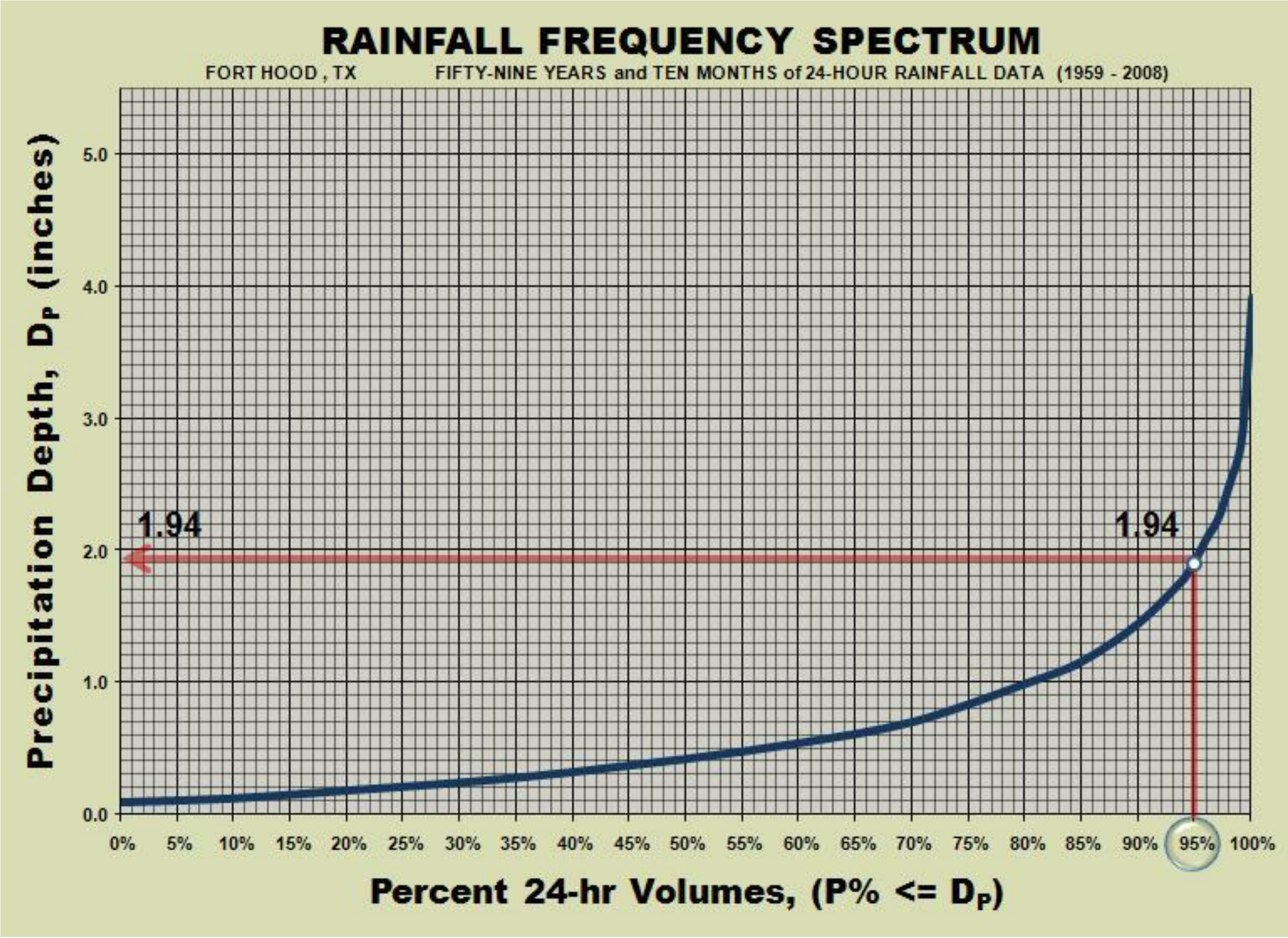

Hydrologic Soil Groups

Group B - Soils in this group have moderately low runoff potential when thoroughly wet. Water transmission through the soil is unimpeded. Group B soils typically have between 10 percent and 20 percent clay and 50 percent to 90 percent sand and have loamy sand or sandy loam textures. Some soils having loam, silt loam, silt, or sandy clay loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

Group C - Soils in this group have moderately high runoff potential when thoroughly wet. Water transmission through the soil is somewhat restricted. Group C soils typically have between 20 percent and 40 percent clay and less than 50 percent sand and have loam, silt loam, sandy clay loam, clay loam, and silty clay loam textures. Some soils having clay, silty clay, or sandy clay textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

Fort Hood

New Building Example

DATE:	14-Jun-11	INSTALLATION:	Fort Hood, Texas
PLANNER:	Bill Sproul		
PROJECT NAME:	New Storage Units		
ROJECT LOCATION:	Fort Hood		
JECT AREA (acres):	23.9	95% RAINFALL	1.94

SELECT THE SITE'S GEN. SOIL TYPE: Silty-Loam HSG = C

PRE-PROJECT LAND COVER	% of SITE	CN		POST-PROJECT LAND COVER	% of SITE	CN
WOODED (fair)				WOODED (fair)		
MEADOW				MEADOW		
BRUSH & WEEDS (fair)				BRUSH & WEEDS (fair)		
LAWN	58.0%	79		LAWN	52.8%	79
ROADS & DRIVES (W* /C&G)	22.0%	92		ROADS & DRIVES (W* /C&G)	22.2%	92
ROADS & DRIVES (W /C&G)				ROADS & DRIVES (W /C&G)		
PARKING, DRIVEWAYS & SIDEWALKS				PARKING, DRIVEWAYS & SIDEWALKS		
BUILDING ROOF	20.0%	98		BUILDING ROOF	25.0%	98
			SELECTION OF OTHER LAND COVER TYPES			
TOTAL %	100.0%			TOTAL %	100.0%	
WEIGHTED AVERAGE CNn =		85.7		WEIGHTED AVERAGE CNd =		86.6

	PRE-PROJECT	POST-PROJECT
RUNOFF VOLUME (95% RAIN) = ACRE-FEET	1.565	1.670
CUBIC FEE	68168	72755
GALLONS	509898	544206

MINIMUM RUNOFF RETENTION VOLUME TO COMPLY WITH EISA 438 VOLUME CONTROL REQUIREMENT

0.105 ACRE-FEET 4,587 CUBIC FEET 34,308 GALLONS

Fort Hood

New Building Example

PLANNING ESTIMATES for LID BEST MANAGEMENT PRACTICES

BIO-RETENTION *[*] Based on an INFILTRATION RATE of 4.43 (Inches/Day) for soils in Hydrologic Soil Group C*

PROPOSED BIO-RETENTION INFILTRATION AREA (square feet) =	23000
ESTIMATED RUNOFF RETENTION VOLUME (cubic feet) =	4,773

VEGETATIVE ROOF

MAXIMUM RETENTION DEPTH BEFORE DISCHARGE STARTS (inches) =	
VEGETATIVE ROOF AREA (square feet) =	
ESTIMATED RUNOFF RETENTION VOLUME (cubic feet) =	0

PERMEABLE PAVING *[*] Based on an INFILTRATION RATE of 4.43 (Inches/Day) for soils in Hydrologic Soil Group C*

PERMEABLE PAVING AREA (square feet) =	
24 HOUR INFILTRATION VOLUME (cubic feet) =	
STONE SUB-BASE VOID RATIO =	0.35
MINUMUM STONE STORAGE DEPTH (inches) =	
ESTIMATED RUNOFF RETENTION VOLUME (cubic feet) =	0

RAIN WATER HARVESTING

CATCHMENT (*ROOF*) AREA DRAINING INTO BMP (square feet) =	
ESTIMATED AVERAGE DAILY USAGE (gallons per day) =	
DESIRED NUMBER OF SERVICE DAYS (3 - 7 days) = 3 / STORAGE CAPACITY (gallons) =	
ESTIMATED RUNOFF VOLUME (95% RAIN) (gallons) =	
ESTIMATED RUNOFF RETENTION VOLUME (cubic feet) =	0

ate limited by CATCHMENT (roof) AREA]

CHECK for EISA 438 VOLUME CONTROL COMPLIANCE

TOTAL ESTIMATED RUNOFF RETENTION VOLUME (cubic feet) =	4,773
RUNOFF RETENTION VOLUME COMPLIANCE TARGET (cubic feet) =	4,587

LID Practices should be sufficient for compliance with Volume Control Requirement

Fort Hood

New Building Example

Summary

- Implementation of Section 438 of the EISA can be achieved by incorporation of GI/LID
- EPA 841-B-09-001 provides technical guidance on implementing the stormwater runoff requirements
- The TR55 model is available to support stormwater modeling analysis efforts
- Potential LID features can be evaluated prior to implementation
- Defensible and consistent hydrologic assessment tools should be used and documented

Questions